WARMING CLIMATE THREATENS SNOWBED AND SNOW PATCH HABITATS IN NORTHERN FINLAND

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SNOWBED AND SNOW PATCH HABITATS

SNOWBEDS

Snow melts by the end of the summer

Vascular plant species, bryophytes, lichens, and algae

Total area and quality estimated to decline

NEAR-THREATENED

SNOW PATCHES

Permanent snow througout the year

Bare ground and rock beneath

Snow algae and snow fungi

ENDANGERED

Snowbed habitat characteristics:
- short growing season
- water saturation
- infertile thin soils
- plants able to subnivean growth


Photo: Soili Jussila


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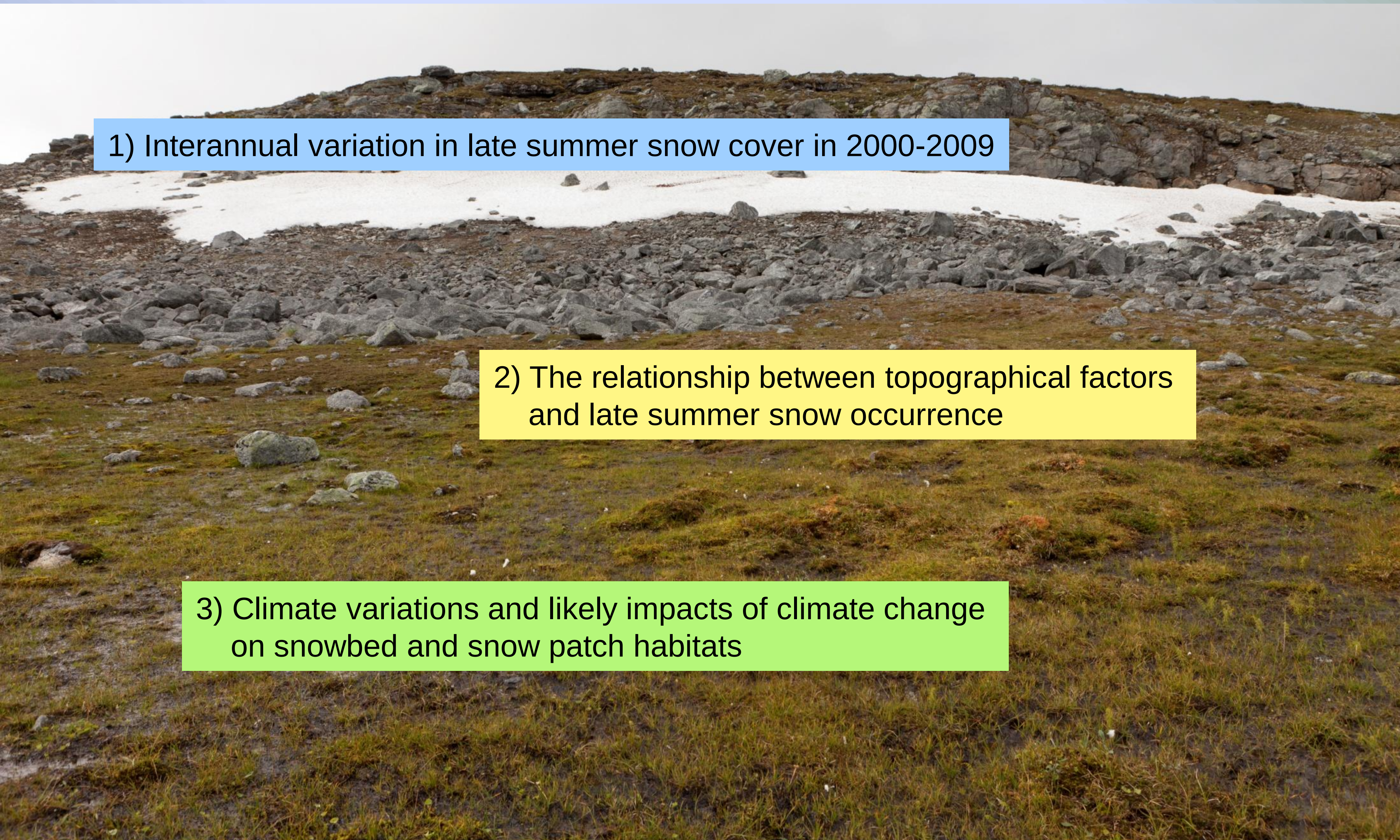
RESEARCH QUESTIONS



1) Interannual variation in late summer snow cover in 2000-2009

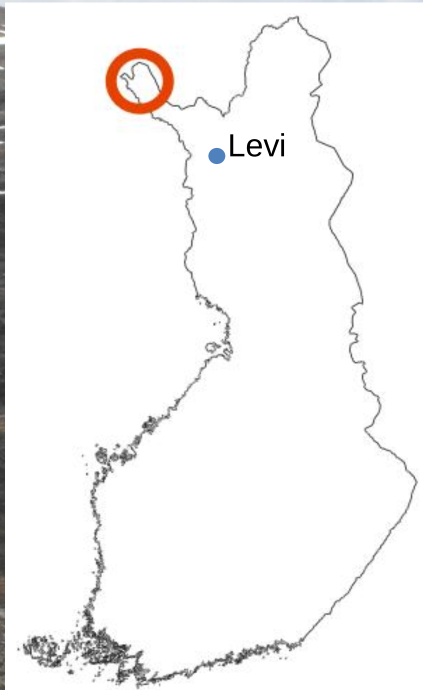
2) The relationship between topographical factors and late summer snow occurrence

3) Climate variations and likely impacts of climate change on snowbed and snow patch habitats

Photo: Soili Jussila

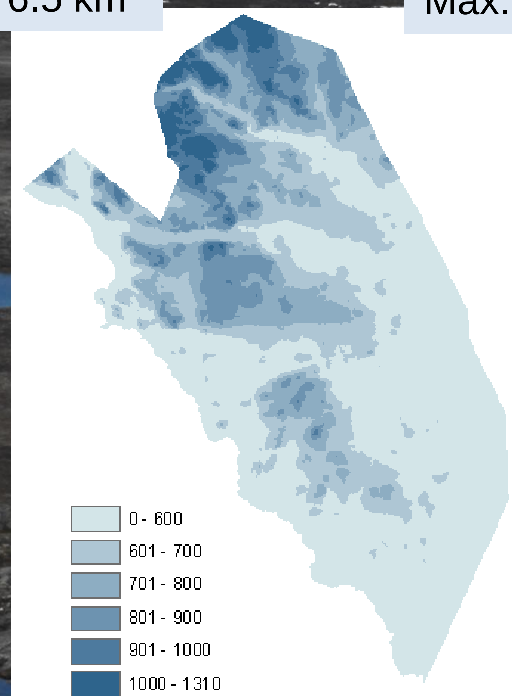
STUDY REGION IN ENONTEKIÖ LAPLAND, NORTHWESTERN FINLAND

20.55-22.4E, 68.5-69.35N



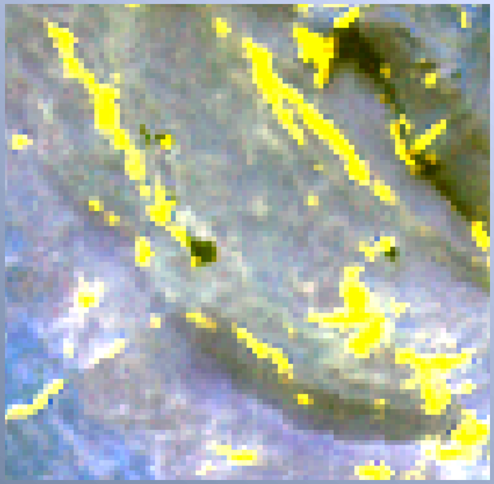
3176.5 km^2

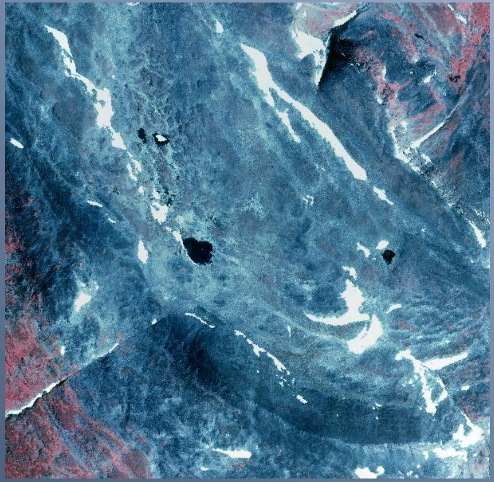
Mean altitude: 627 m
Max. altitude: 1310 m



Subarctic birch forests (approximately up to 600 m) and treeless alpine tundra

MAPPING THE LATE SUMMER SNOW





Satellite data:

Landsat ETM+: 27 July 2000 (195/11,12)
Landsat TM: 30 July 2004 (195/11,12)
27 July 2006 (196/11,12)
4 August 2009 (196/11,12)

Snow extraction:

1) Normalized Difference Snow Index
NDSI = (band 2 – band 5)/(band 2 + band 5)

2) Unsupervised classification to remove water bodies

Accuracy assessment:

Landsat ETM+ 27 July 2000 and aerial photographs 25 July 2000
- 500 points; 250 classified as snow and 250 as other land cover

Overall classification accuracy = 95.2%.
Error of commission: snow = 6.3%, other land cover = 3.2%
Error of omission: snow = 3.3%, other land cover = 6.2%

OCCURRENCE OF LATE SUMMER SNOW?

Interannual variation – a pixel-level analysis at 30 m resolution

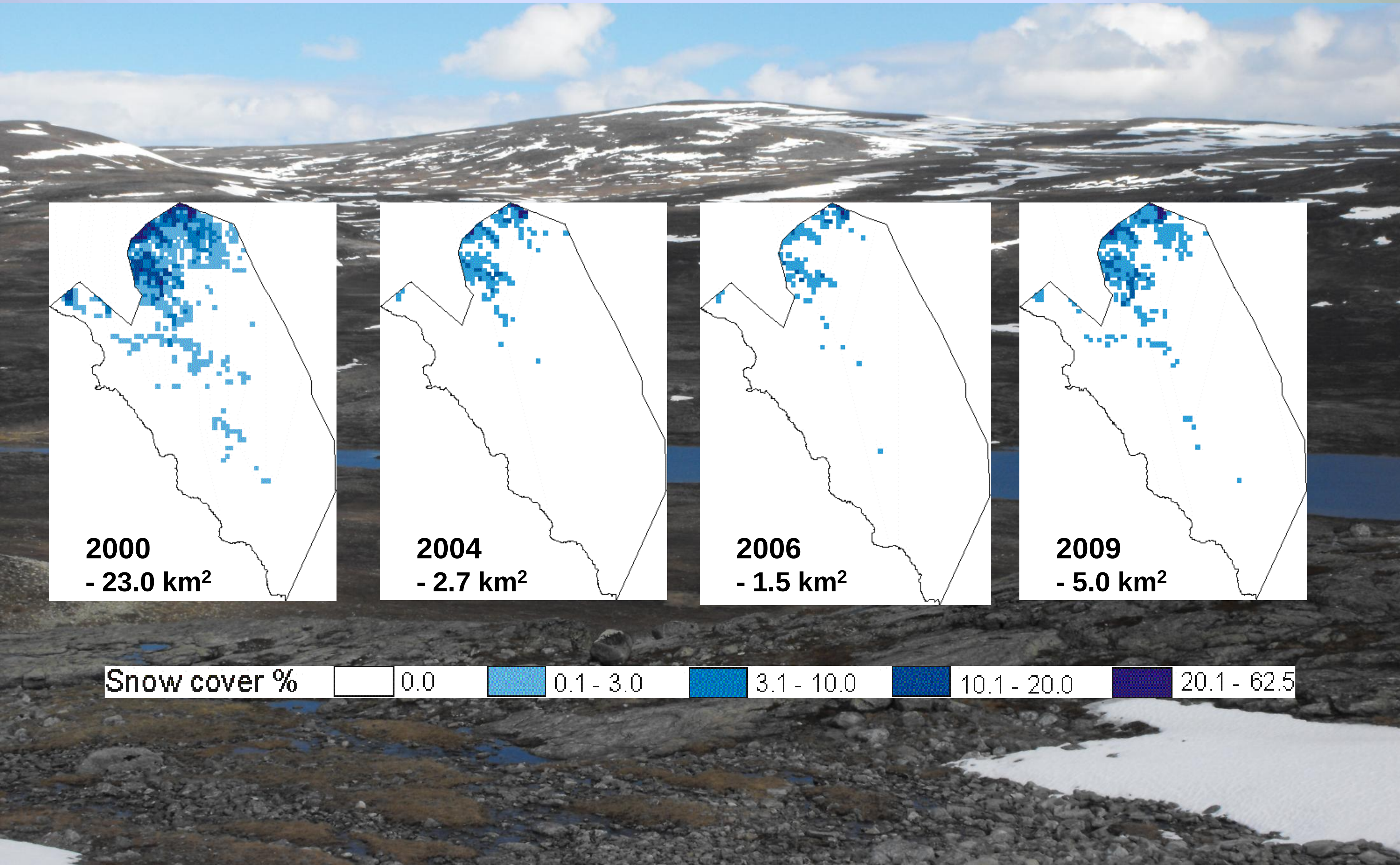
Total coverage and spatial distribution in relation to altitude and aspect in years 2000, 2004, 2006, and 2009

Snow occurrence years – a grid square analysis at 1 km resolution

Snow presence (1 - 4 years) versus snow absence (0 years) in relation to altitude, terrain ruggedness, insolation and aspect; Mann-Whitney U-test

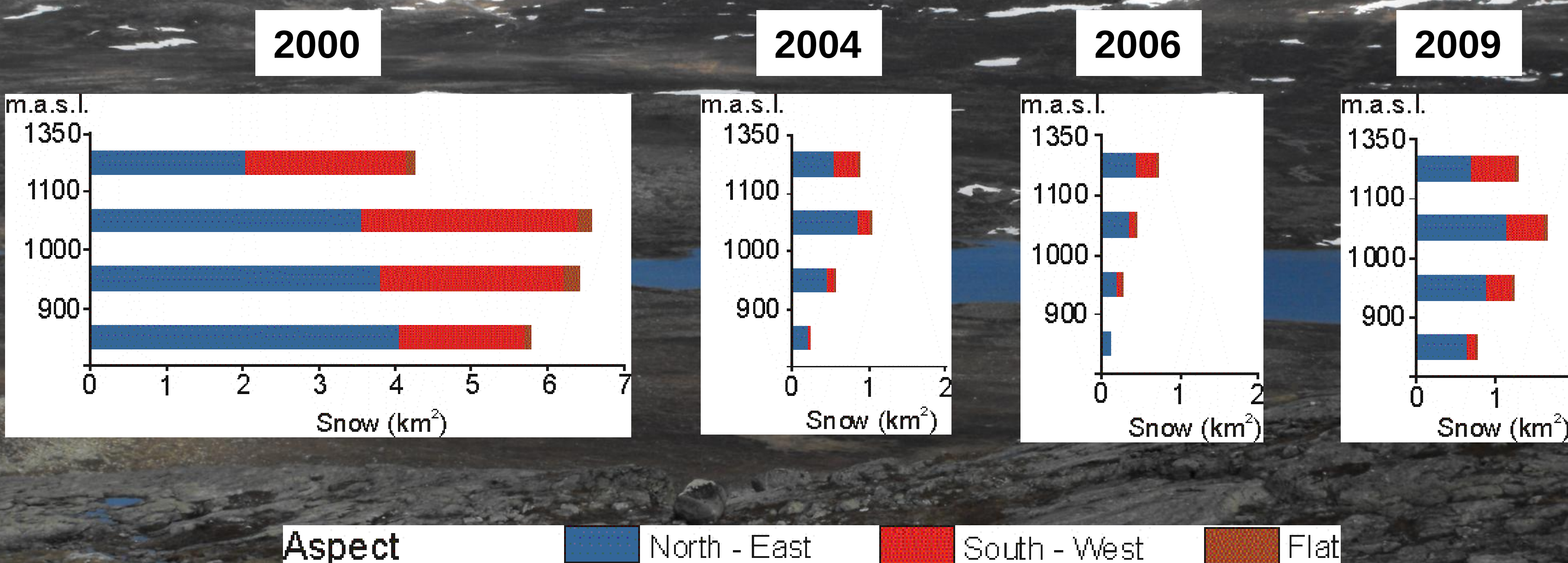
A generalized additive model (GAM) smoothed with 3 degrees of freedom for the number of snow years (0 – 4 years)

SPATIAL DISTRIBUTION OF LATE SUMMER SNOW

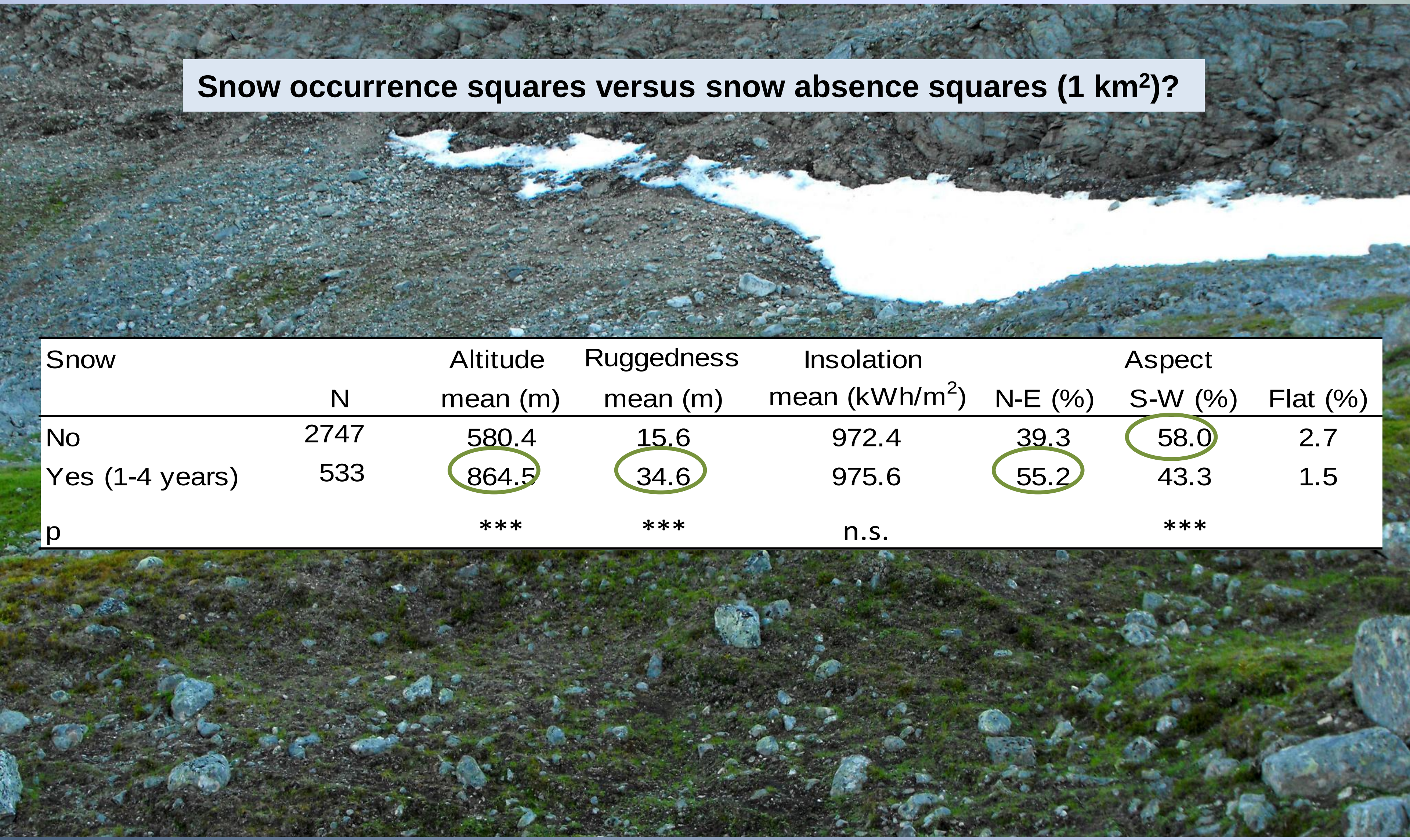


SPATIAL DISTRIBUTION OF LATE SUMMER SNOW

in relation to altitude and aspect at 30 m resolution



THE OCCURRENCE OF LATE SUMMER SNOW



Snow occurrence squares versus snow absence squares (1 km^2)?

Snow	N	Altitude mean (m)	Ruggedness mean (m)	Insolation mean (kWh/m^2)	Aspect N-E (%)	S-W (%)	Flat (%)
No	2747	580.4	15.6	972.4	39.3	58.0	2.7
Yes (1-4 years)	533	864.5	34.6	975.6	55.2	43.3	1.5
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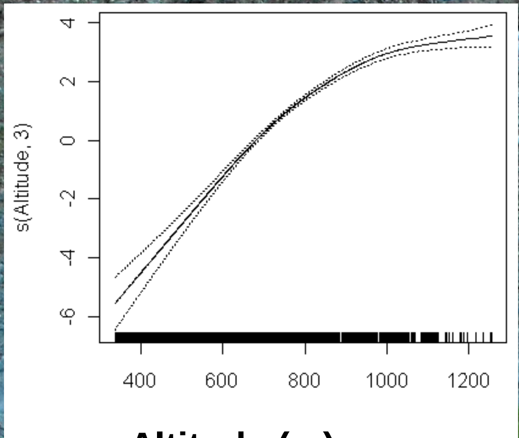
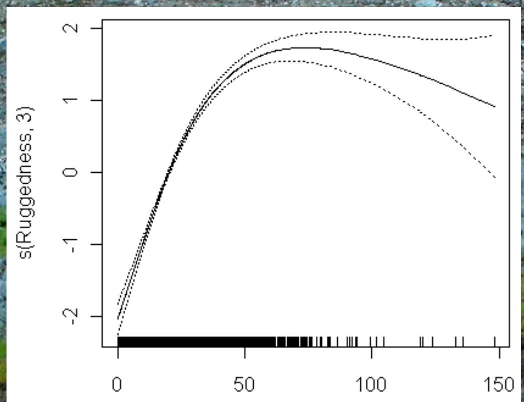
THE OCCURRENCE OF LATE SUMMER SNOW

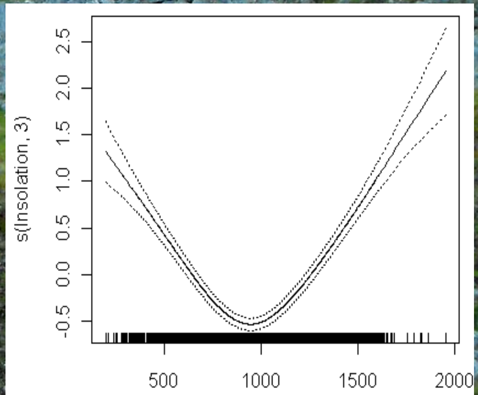
Explanatory factors for the number of snow years (0 - 4) in 1 km^2 grid squares?



Altitude (m)
-Univariate: 66.5%



Ruggedness (m)
-Univariate: 27.2%



Insolation (kWh/m^2)
-Univariate: 8.3%

Total model explained 72.7% of the variation

Aspect
-Univariate: 2.5%

RECENT CLIMATE VARIATIONS AND PROJECTIONS

Recent climate variations

Climate data for 1995 – 2009:
10 km resolution grid data (Finnish Meteorological Institute)

Climate change projections

ENSEMBLES (Ensembles-Based Predictions of Climate Changes and Their Impacts)

11-model means; 25 km resolution

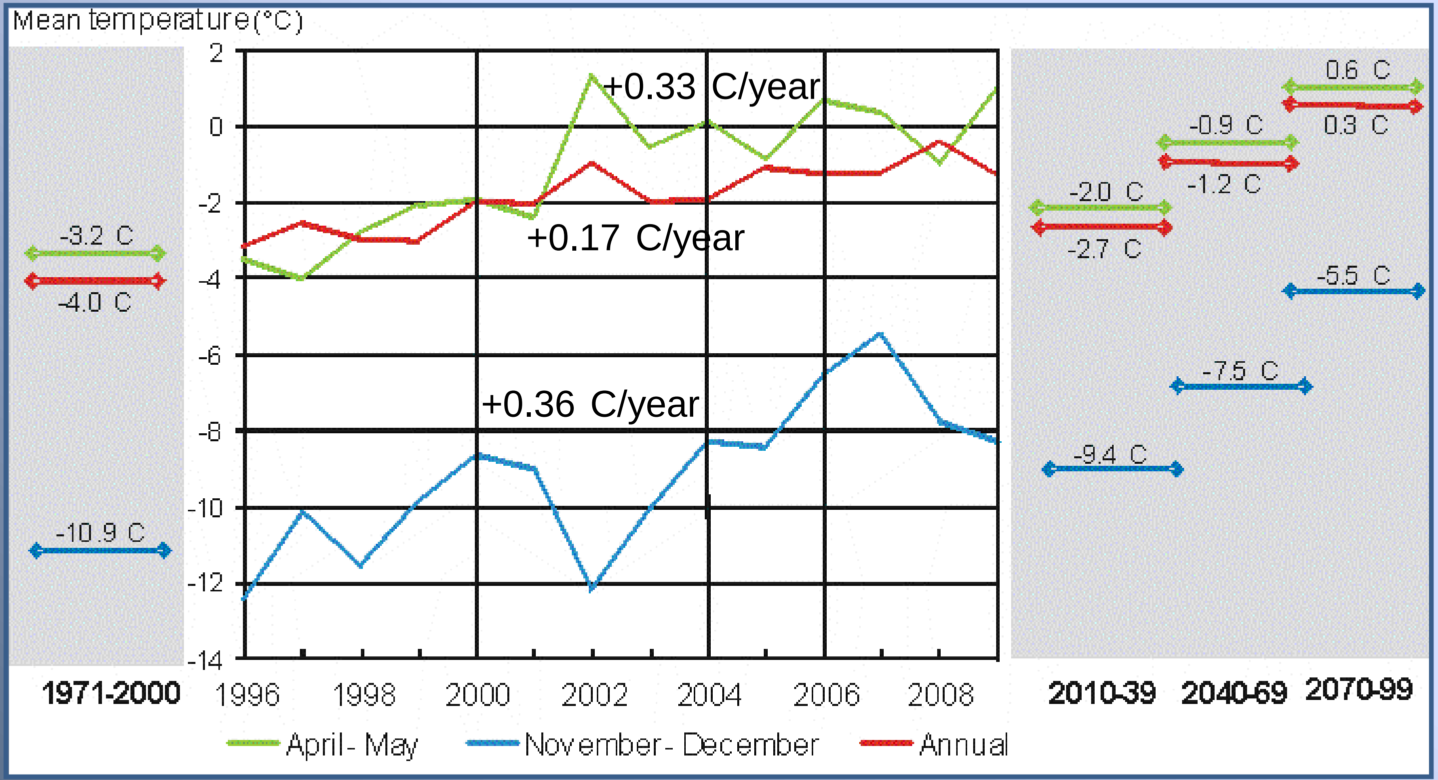
PRUDENCE (Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects) project

50 km resolution

Räisänen, J. and J. Eklund, 2011: 21st century changes in snow climate in Northern Europe: a high-resolution view from ENSEMBLES regional climate models. *Climate Dynamics.*

Jylhä K, Fronzek S, Tuomenvirta H, Carter TR & K Ruosteenoja (2008). Changes in frost, snow and Baltic sea ice by the end of the twenty-first century based on climate model projections for Europe. *Climatic Change* 86, 441–462.

RECENT TEMPERATURE TRENDS AND FUTURE PROJECTIONS



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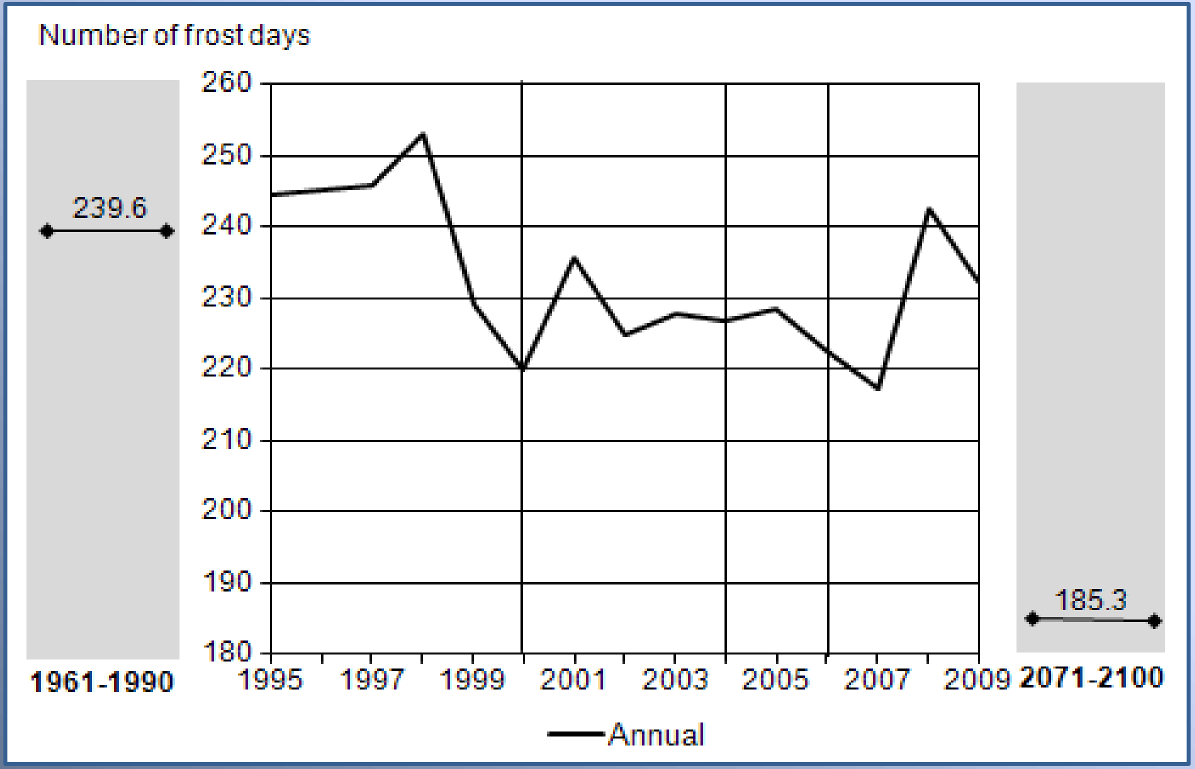
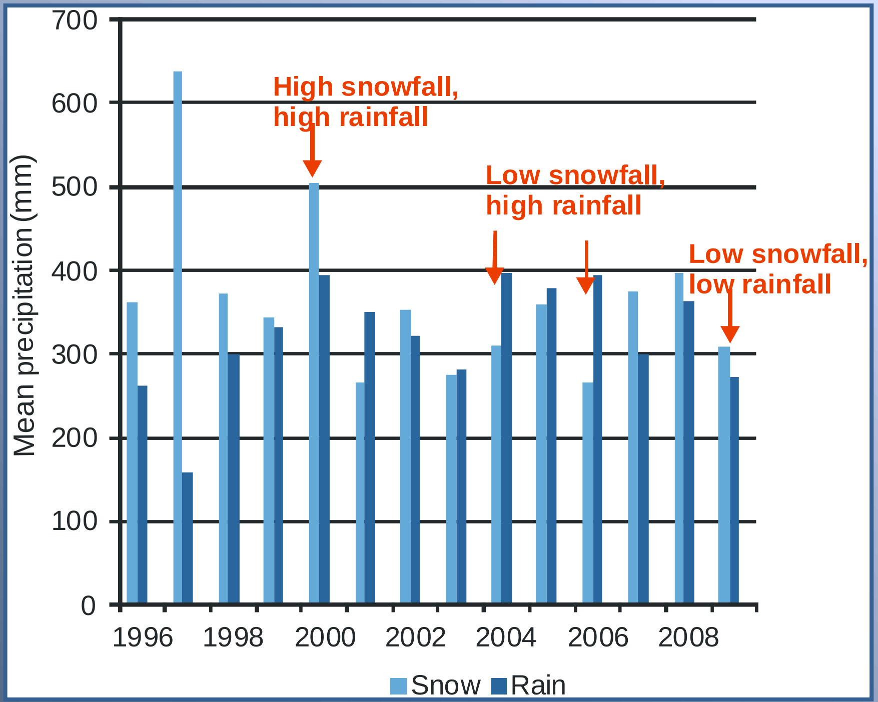
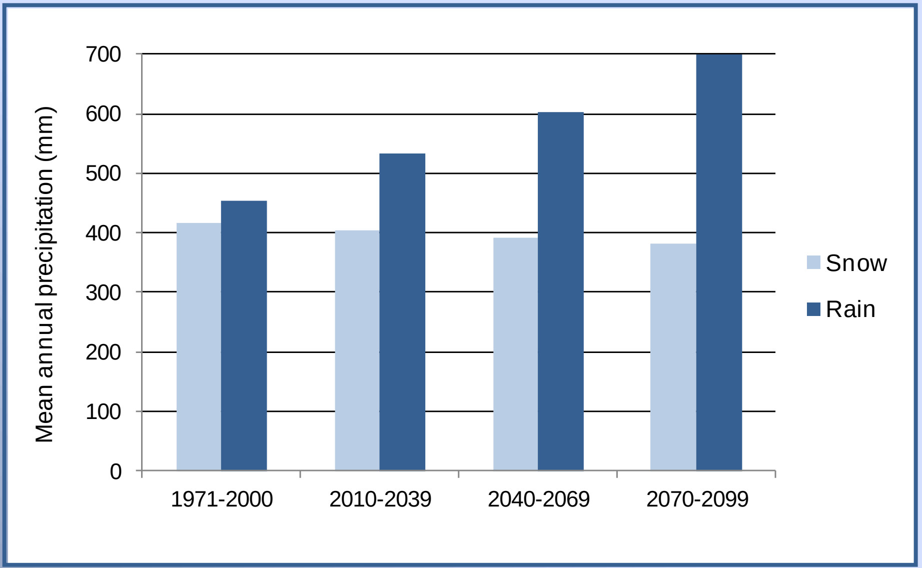
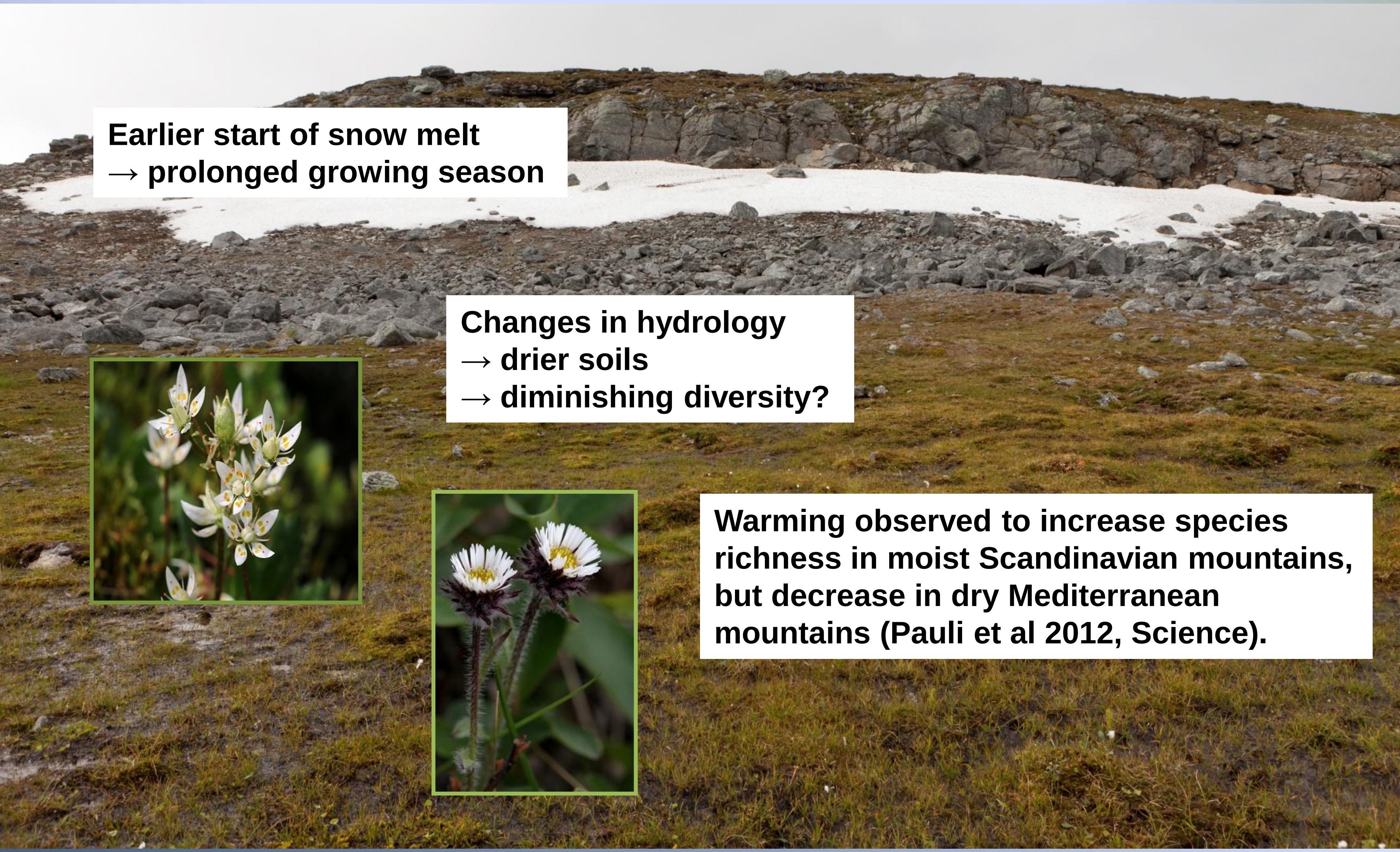


PRECIPITATION AMOUNTS AND FUTURE PROJECTIONS





LIKELY IMPACTS OF WARMING CLIMATE



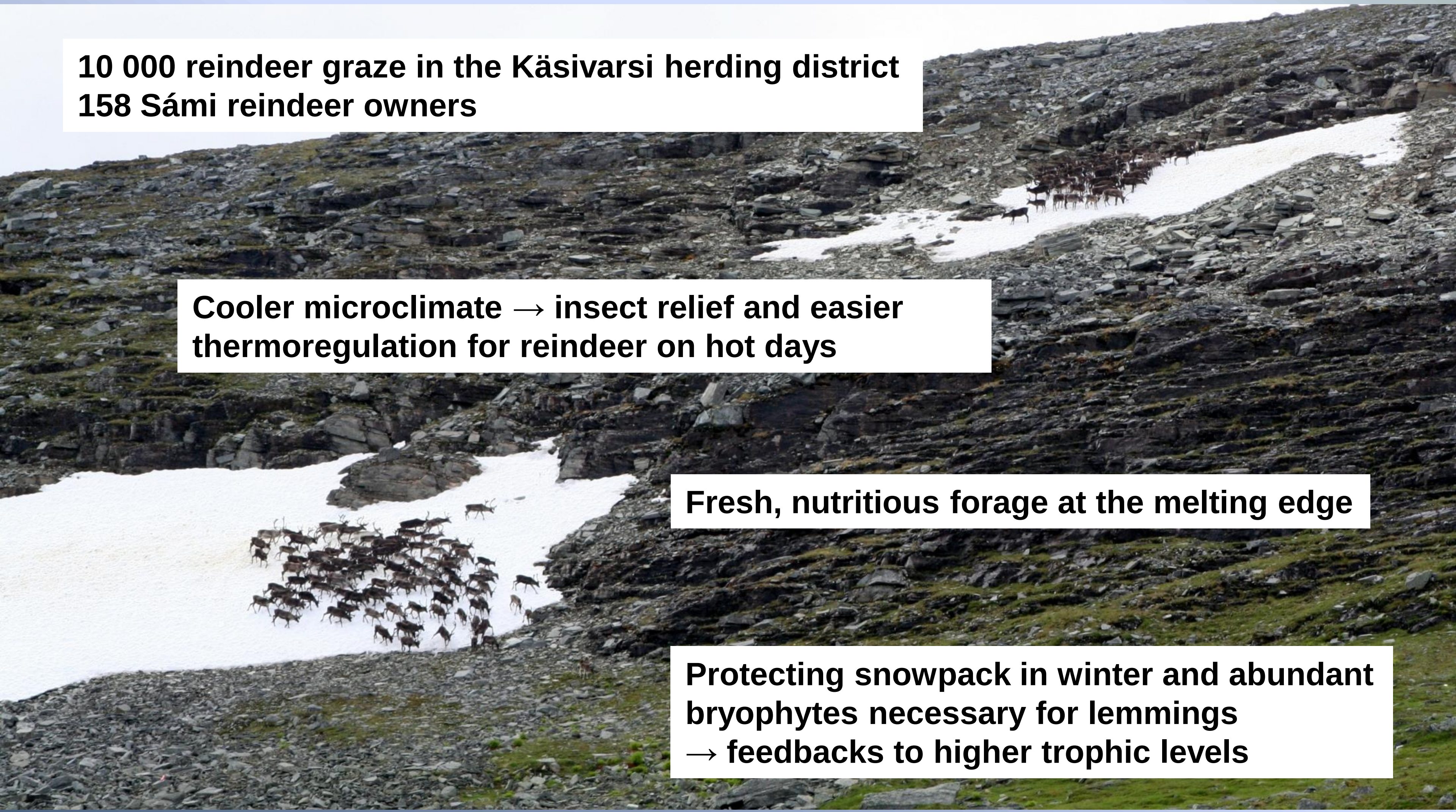
Earlier start of snow melt
→ prolonged growing season

Changes in hydrology
→ drier soils
→ diminishing diversity?

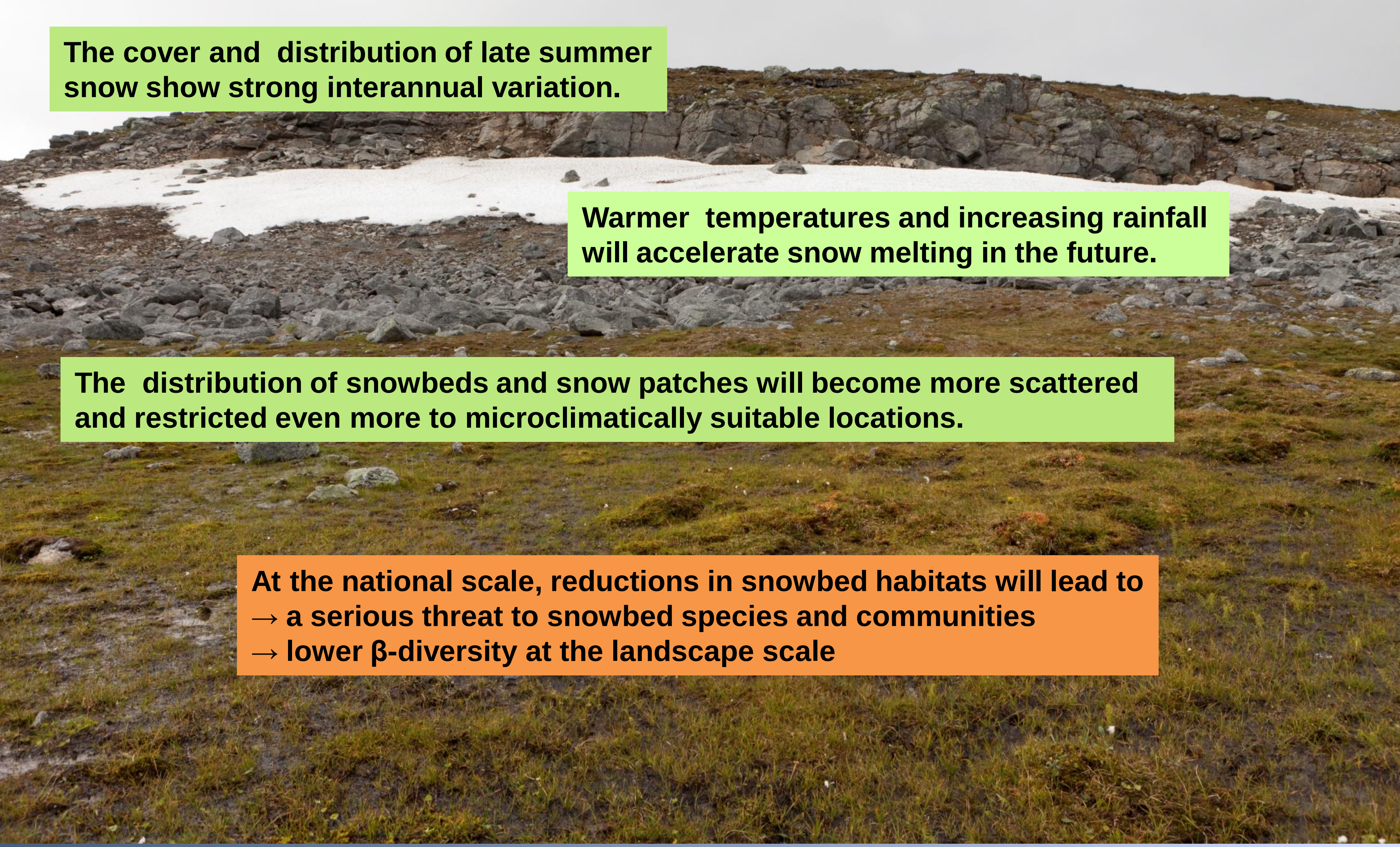
Warming observed to increase species richness in moist Scandinavian mountains, but decrease in dry Mediterranean mountains (Pauli et al 2012, Science).

Photos: Soili Jussila

EFFECTS ON ECOSYSTEM SERVICES



CONCLUSIONS



The cover and distribution of late summer snow show strong interannual variation.

Warmer temperatures and increasing rainfall will accelerate snow melting in the future.

The distribution of snowbeds and snow patches will become more scattered and restricted even more to microclimatically suitable locations.

At the national scale, reductions in snowbed habitats will lead to
→ a serious threat to snowbed species and communities
→ lower β-diversity at the landscape scale

Photo: Soili Jussila

THANK YOU!